

COST EFFECTIVE DESIGN OF NON-CONTACT VOLTAGE TESTER

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Abstract: Electricity is one of the key energies that is driving almost every automated device from household daily life gadgetsto heavy instruments drivenin the industries. Electricity is distributed from power plants to the industries and to the house through transmission lines. Electricity drives any electrical equipment in the presence ofalternating (AC)voltage and current. AC voltage drives the AC current to flow through the wire and drive the equipment.But due to internal faults in wire, the current cannot come out of the power plug where the devices to be driven need to be connected. In such cases of faults, the best way is to detect the presence of voltage in power plug is toputan electrical tester in the plug point. But this technique of detecting the presence of voltage at the power point plug could be dangerous for life if is it is mishandled by untrained person. Hence in this paper a wireless, non-contact voltage tester has been proposed that can proved to be an instrument safe for human life specially for the persons who are not trained at all.

Key words: *Contactless detector, voltage detector, voltage tester, wireless tester*

1. INTRODUCTION

Electricity has become a basic need for humanity as almost everything we use in our daily life run on it. But if we do not take necessary safety precautions while working with electricity or electrical appliances, it can cause severe injuries or even death. So, before working with AC Mains supply near junction boxes like installing a new device for example, we must turn off the supply and verify that there is no voltage in the switch board. Voltage Testers are devices that detect and indicate presence of voltage in power cables, electrical cords, lighting fixtures, circuit breakers, wires, power outlets etc. A Non-Contact Voltage Tester, as the name suggests, is a voltage detector device that doesn't need any contact with cables, cords or outlets. In this project,

I have designed a simple battery powered non -contact Voltage Tester Circuit that can be used to verify the presence of voltage near all the above-mentioned places.

Researchers have proposed many methods that have aimed at detecting the presence of electric filed through a current conducting wire. S. Wei, L. Zhang, W. Gao and Z. Cao, in 2011 [1] have proposed a method that aims at non-contact voltage detection in severe environmental conditions present in coal mine. This method uses field effect transistor to sense the electric field on the principle of capacitance effect. In any electric wire, the flow of electron or presence of charge is detected in a different way rather than the conventional way. The direct way of measurement is not suitable for coal mines because the insulation of conductor needs to be removed, whereas the other indirect methods incorporating the photo electric or electromagnetic effect requires very high sensitivity that increases the cost of the detection device. This technique uses a measuring probe which is connected to the Gate terminal of the FET. The measuring probe is induced by electric field from the current carrying conductor. The weak voltage produced from the measuring probe is amplified by an instrumentation amplifier.

The current produced over here requires an instrumentation amplifier and the AC output of the amplifier is rectified by rectifier circuit and stabilized by using a voltage regulator IC. This device indeed works great for coal mines but it does not work at high electrical interference at severe environmental condition on earth, e.g. at stormy seasons. Hence for proper operation it requires a very high shielding at the enclosure as well as the probe.

The researchers D. Lawrence, J. S. Donnal, S. Leeb and Y. He [2] in 2016, have presented a capacitively coupled non-contact voltage sensor, that can measure line voltages from low level to very high level. The challenge behind the non-contact measurement of AC line voltage is the signal interferences from other sources. This paper presents a sensor that improves the performance as well as the operating range of voltages to be measured. The authors claim that this sensor system not only increases the sensor resolution but also reduces the circuit cost. The basic principle of operation involves the use of parasitic capacitance C_p that is developed between sensor plate and nearby current conducting wire. Since the parasitic capacitance is very small, hence the sensor plate is attached to the ground through a high value of resistor. The sensitivity of the sensor is directly proportional to frequency and inversely proportional to the distance between conducting wire and sensor plate. For improved signal measurement without any noise, differential measurement is obtained from two stacked sensor plates. Parasitic

capacitance is therefore nullified by the differential measurement, whereas equivalent additional capacitance is produced between each plate and ground. It has been found that, if the distance between the differential plate is smaller than the distance of the plates from current conducting wire, the sensitivity of differential sensor becomes inversely proportional to the square of distance between the wire and sensor plates.

The fabrication has been meticulously done on a standard PCB with two bottom layers of PCB separated by 0.25mm prepreg having dielectric constant of 4.5 approximately. INA332 amplifier has been used instead of AD8421 to reduce the cost. Two digital FIR filters have been used to remove noise which have been proved to be better than the existing analog filters. But both analog and digital filters offer finite time delay. As a result, real time reading cannot be obtained. The experiment result shows that with various loads under switched on or switched off condition, the sensor is able to distinguish read power and reactive power. The experiment results show that this non-contact voltage sensor allows the measurement of high voltage without the need of high voltage isolation. To increase the accuracy, calibration accuracy of the reference voltage is required. The author of this paper therefore assures that their sensor is able to provide accuracy and disturbance rejection when electromagnetic interference occurs.

2. PROPOSED SYSTEM

The author in this paper has proposed a system that implements the basic rule of electromagnetic induction in a wire due to the presence of magnetic field produced by another current carrying conductor. It is known that an electric current, or a moving electric charge, through a conductor produces a magnetic field. As per the statement of Biot-Savart law [3], value of the magnetic field at a point near the current carrying conductor is considered the sum of all the contributions from each small element, or segment, of the conductor. The Biot-Savart law also states the value of the magnetic field at a point is directly proportional to both the value of the current in the conductor and the length of the current-carrying segment under consideration. The value of the electric field at a given point is greatest when the short segment of current makes an angle of 90° with the current segment. The less the angle, the electric field becomes smaller and diminishes when the particular point of interest lies on the line in which the current carrying element is a segment. In addition, the magnetic field at a point due to a current carrying conductor is inversely proportional to the square of the distance from the current

element that produces it.

Any current carrying conductor produces a small magnetic field around it and the type of magnetic field depends on the type of current passing through the conductor. In case of alternating current, when it flows through the conductor, the magnetic field produced around the conductor also changes its direction periodically. This variation of magnetic field is used to indicate whether voltage at this point is present or not. In the proposed design, shown by Figure.1, three NPN Transistors have been used. A shielded copper wire of 12cm is attached to the base of a transistor Q1 shown by the Fig. 1. Whenever the shielded copper wire is kept within 1 cm from the switch board by keeping the switch on, according to the Faraday's law of electromagnetic induction, an emf is produced in the wire which is very small.

The bipolar junction transistor Q1, works as an amplifier and increases the voltage amplitude produced due to electromagnetic induction in the antenna. According to the function of bipolar junction transistor (BJT), the induced emf at the base terminal produces instantaneous base current which in turn produces the instantaneous collector current (i_c) and instantaneous emitter current (i_e) in a BJT. Instantaneous emitter current produced in BJT Q1 is applied to the base of another BJT Q2 in the circuit to provide additional voltage gain of to the AC signal. The voltage gain of BJT is the product of current gain and output resistor. Transistor Q2 acts as an amplifier and it drives the Base of another transistor Q3 with which a light emitting diode (LED) is connected as load. The

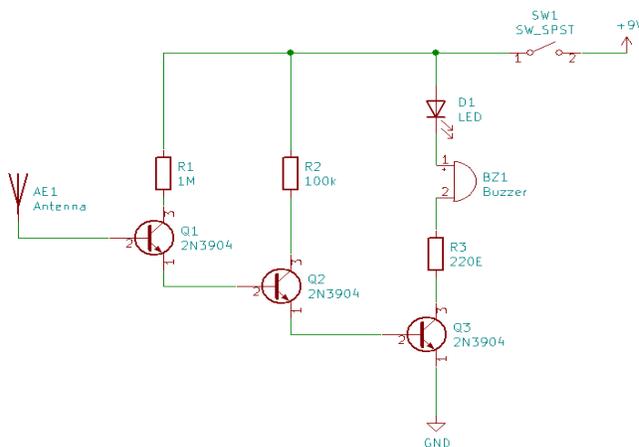


Figure 1: Circuit diagram of non-contact voltage tester

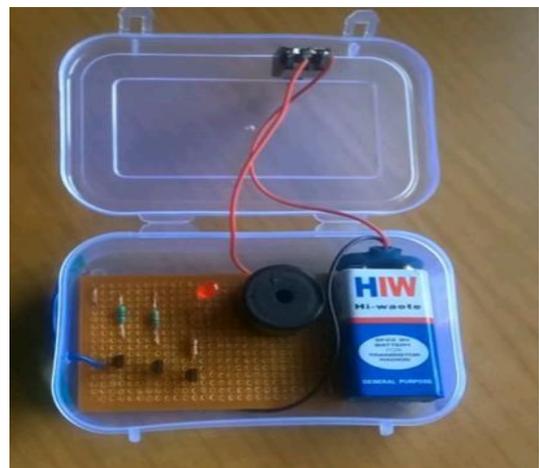


Figure 2 Prototype of the proposed system

output of the BJT Q3 produces enough voltage at the collector terminal to indicate the presence of emf by glowing the LED. The small signal current gain obtained from manufacturer specification for the specified BJT 2N3904 [4] is approximately 400 for 1KHz frequency with a

DC collector current of 1mA. In this circuit the transistors are connected in cascaded configuration to increase the small signal current gain which results to be the product of individual current gain of three transistors.

Additionally, a small buzzer is connected in series with the LED to provide sound alarm whenever circuit detects an AC voltage. The prototype of the proposed design is shown in Figure 2. Also, the list of components used in the prototype and the cost has been indicated by Table.1

Table 1. List of components

Sl. No	Component Type	Specification	Quantity
1	NPN TRANSISTOR	2N3904	3
2	Carbon Resistor	1 M Ω	1
3	Carbon Resistor	100K Ω	1
4	Carbon Resistor	220 Ω	1
5	LED	5mm	1
6	Buzzer	5 Ω	1
7	Switch	SPDT	1
8	Prototype builder board	NA	1
9	9 Volt battery	Alkaline	1
10	Plastic case	50mm x 50mm	1

3. Results and discussion

The system proposed by the author is quite cost effective and energy efficient. It is able to run with a voltage as low as 5 volts without the buzzer present. But to drive the alarm system, the device runs presently with a 9-volt battery. The total cost with enclosure may come down to within Rs/- 50. This device produces quite good result in detecting the voltage near to the power plug with a distance of 1 cm approximately from the plug. But due to the less ampere requirement for household wiring, this device cannot detect the electromotive force or voltage in concealed wiring. It is because, the magnetic field produced in this case is not enough to produce the required amount of current due to electromagnetic induction to be detected by the device.

Also, the induced emf in the wire can be increased by increasing the number of turns in the wire. Though this device has been tested for detecting the emf present in home wiring, but its ability to detect the emf under noisy environment is yet to be tested. Measurement accuracy and the display of proper voltage from the induced emf has also not been performed in this prototype to minimize the cost. Its future applications can be extended to detect very low AC voltage present in high frequency cable lines.

4. CONCLUSION

This system is a simple non-contact voltage tester which can be used to detect the presence of AC voltage in power lines. But it is expected to perform well in very high voltage lines like power line cables, high voltage switch boards, junction boxes, circuit breakers etc. Since it is battery operated prototype, the prototype can be used as small portable device. Apart from that, it's applications can be extended in various fields like security, communication, irrigation, entertainment, environment etc. with proper shielding of the device from external interference produced from other sources.

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